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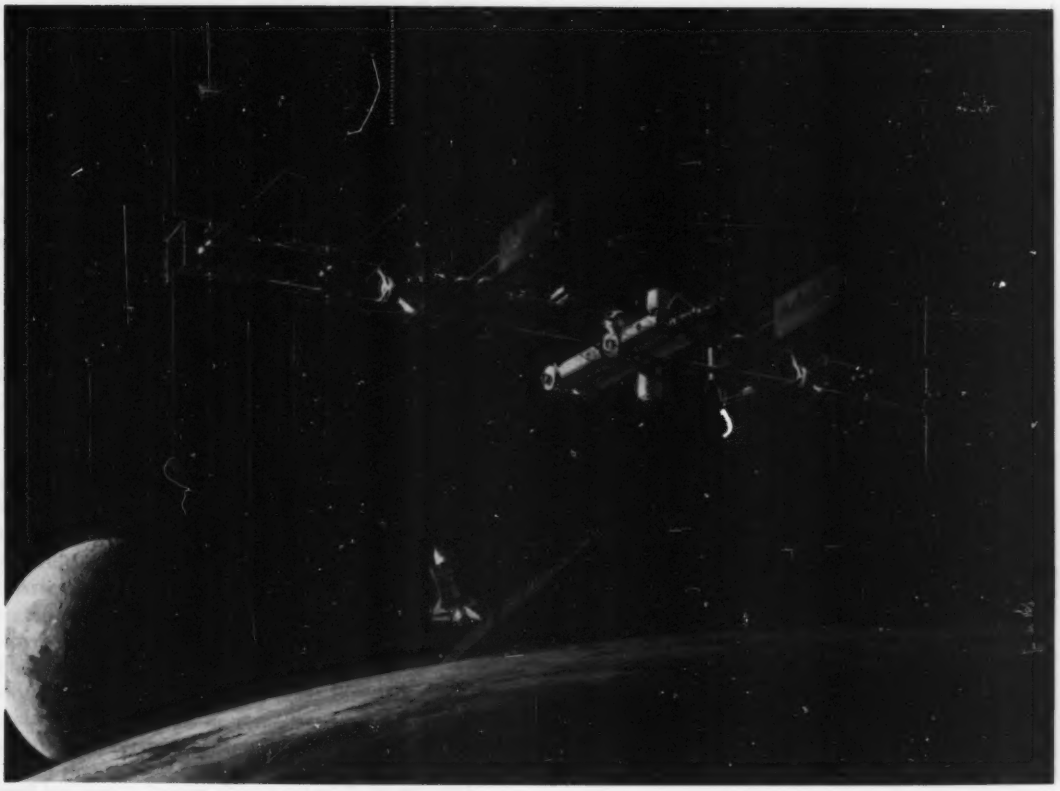
THE NEXT LOGICAL STEP



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Also in this issue:
AA Leonard Fisk's Speech on "Solar System Exploration: Origins, Evolution, and Future Prospects"

A Special Message from the Administrator

The strength of any team is the sum of all its parts. And so it is the NASA. The NASA team has taken us to the Moon and to worlds beyond. And that same team - at all of our centers and at Headquarters - will give the nation a permanent presence in space by the mid-1990s. We can and will do it by working together.

The Space Station is truly important to the future of the United States. No longer limited to occasional spectaculars, space has become an essential, almost commonplace dimension of national life. Among other things, space today is an arena of competition with our allies and with our adversaries. It is a place of business, where private companies can and do realize profits. It is a field of research, for the development of technology and the conduct of science. It is also an avenue of cooperation with our allies demonstrating the peaceful use of space for the benefit of all.

The Space Station will play a critical role in each of these endeavors. A unique and versatile concept, the Space Station will shape what we do in space and how we do it. And by doing so, it will be the centerpiece of our Nation's future in space.

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About the Cover

"Space Station", acrylic by Vincent Di Fate

Artist concept of the permanently manned international Space Station complex to be placed into a 300 mile high equatorial orbit by NASA in the mid 1990's. The Space Station will serve as an orbiting research facility to enable scientific exploration, technology development and private sector research in space and will ultimately serve as the staging base for continued manned and unmanned exploration of the solar system.

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Administrator's Column

(The following is an excerpt from NASA Administrator Dr. James C. Fletcher's remarks at the University of Missouri at Rolla on Dec. 20, 1987.)

The key to building our future in space will be the permanently-manned Space Station we will be operating in low Earth orbit in the mid-1990s. The Space Station will open a new era of expanded discovery, opportunity and development in space.

With the Space Station we'll no longer be visitors to space; we'll be permanent residents.

The Station will signal America's commitment to leadership and to our long-term future in space. It will give us a place to do the long-term research, technology development and other work necessary to advance the human presence into the solar system. In the process, the Space Station will increase scientific knowledge, stimulate the development of new technologies and help realize the commercial potential of space.

The Space Station will be a truly revolutionary step in space operations. It will be assembled and maintained in orbit. It will be permanently manned and continuously operated. And it will require international management and technical program coordination because of the expected participation of our foreign partners in Europe, Japan and Canada.

Unlike an instrumented satellite, spacecraft or launch vehicle, we expect the Space Station will evolve as our requirements for it continue to grow. So, as the Station develops, its capabilities will grow gracefully.

Assembling and maintaining what will be the largest structure ever put in space, some 220 miles above the Earth's surface, will be an engineering challenge of the highest magnitude. We must not only build this structure, but must keep it on its orbital course, while at the same time, maintain its structural integrity and stability.

And that must be done in the harsh environment of space, where without proper life-sustaining equipment, humans would die quickly.

The Station will be built step-by-step to provide, at first, for a man-tended capability; and finally, for the permanent presence of humans.

The Space Station will have to be assembled and checked out in space, where minor hardware adjustments outside of a Spacecraft are a major challenge to an astronaut in a bulky space suit. Therefore, we will have to develop hardware and procedures to facilitate these tasks.

Once assembled and operational, how will we keep the Space Station in first-rate shape? Historically, the space industry has not planned for repair of operational systems in space. The Space Station will be operating for 30 years or more. During that period, active components might fail or wear out and will have to be replaced. Access to these components will have to be assured for routine maintenance, repair and/or replacement of existing systems.

Maintenance in orbit will require a configuration control program more comprehensive than for any previous manned space flight program.

For example, the record keeping on such items as parts qualification tests, interchangeability, manufacturing specifications and maintenance and interface data will fill technical data files kept over a 20-year period. Clearly, even out best engineers and space mechanics will benefit here from standardization in engineering design practices. And we intend to work toward that goal.

During the Space Station's very long lifetime, experiments will vary. Therefore, crews must be trained to cope with varying configurations aboard the Station. We plan to meet this challenge through an integrated training system in which astronauts will perform their duties in a simulator to be configured exactly as the on-board Space Station will be. In this way, successive crews will be able to operate efficiently, and thereby help to increase the scientific return of Space Station experiments.

I've mentioned only some of the exciting challenges we will face over the next few years and beyond, as we build the infrastructure for permanent occupancy of space.

After nearly three decades in space, America has only begun to tap its potential for human betterment. Yet, our experience has produced rewards rich beyond measure and has contributed countless benefits to mankind.

Paving the road to space will take courage, skill and ingenuity. Most of all, it will take determination and long-term commitment from the American people.

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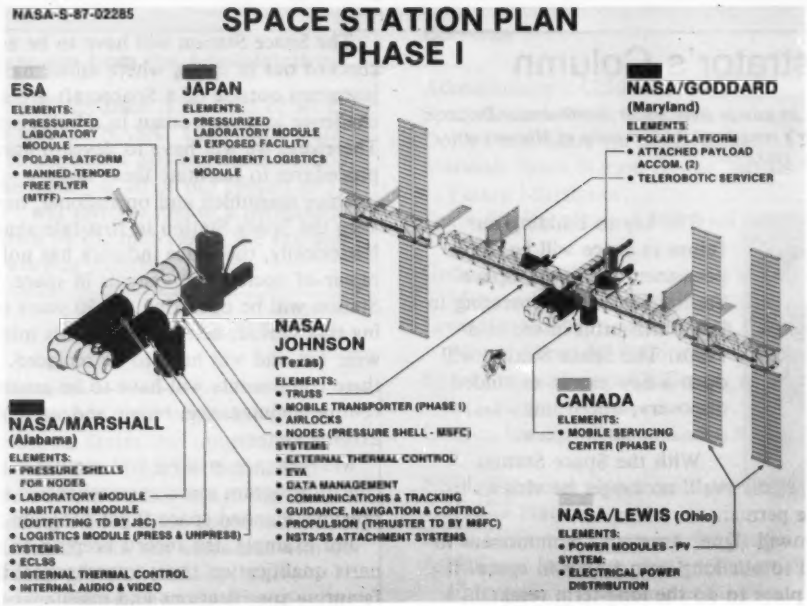


In 1984, the President directed the National Aeronautics and Space Administration (NASA) to undertake the development of the Space Station, the next step in a broad-based U.S. civil space program to develop spaceflight capabilities and to exploit space for scientific, technological, and commercial purpose. Under that direction, NASA awarded, in 1985, contracts for parallel definition and preliminary design (Phase B) studies. Those studies have been completed and the Space Station Program (SSP) is now ready to proceed into the final design and development phase (Phase C/D), leading to a permanently manned Space Station to be operational in the mid-1990's. Now it is time to acquire the design, development, test, and evaluation (DDT&E) and delivery of the Space Station, including related early operations support. The Space Station Phase C/D requirements appear in four work packages (WP's), each under the cognizance of a NASA field installation, and each reflecting assigned Space Station responsibilities.

Work Package-1 Marshall Space Flight Center

Laboratory Module
Habitation Module
Logistics Elements
Node and Airlock System Components
Environmental Control and Life Support
Internal Audio/Video
Internal Thermal Control
Node Structure
Berthing Mechanisms/Hatches
Manned Systems Components (MOU)

Work Package-2 Johnson Space Center

Resource Nodes
Integrated Truss Assembly
Mobile Transporter
Propulsion Module Airlocks
STS/SSPE Attachments
EVA, External Thermal Control, Assembly and External Maintenance, GN&C, C&T, and DMS Systems

Work Package-3 Goddard Space Flight Center

Polar and Co-orbiting Platforms
Attached Payload Accommodations
Customer Servicing

Work Package-4 Lewis Research Center

Electric Power System

NASA Selects Aerospace Firms to Design and Develop Space Station

On December 1, 1987 NASA announced selection of four aerospace firms for final negotiations leading to award of cost-plus-award-fee contracts to design, develop, test and evaluate and deliver the components and systems comprising the permanently manned Space Station to be placed into Earth orbit in the mid-1990's.

The work to be performed is broken down into four packages each containing a unique but interdependent portion of the Space Station. Each work package is divided into 2 phases. Phase I covers the currently approved elements of the Space Station program. Phase II is an option for possible future enhancement of the Space Station's capabilities.

The four companies selected for the Phase I effort are:

- Work Package 1
  Boeing Aerospace Company, Huntsville, Ala.

- Work Package 2
  McDonnell Douglas Astronautics Co., with locations in Huntington Beach, Calif., and Houston

- Work Package 3
  General Electric Company, Astro-Space Division, with locations in Valley Forge, Pa., and East Windsor, N.J.

- Work Package 4,
  Rocketdyne Division, Rockwell International, Canoga Park, Calif.

Total cost proposed by the four companies is approximately $5 billion for the Phase I effort and approximately $1.5 billion for the Phase II priced-option effort. The combined work package prime contractor cost, should the Phase II option be exercised, would be approximately $6.5 billion.

The Space Station budget for the current fiscal year is over $525 million. Congress appropriated $425 million for the Space Station Program for Fiscal Year 1988, and there is approximately $100 million more, appropriated for Space Station activities in the previous fiscal year but not released, which NASA will request for Space Station development work this year. Andrew J. Stofan, associate administrator for Space Station, said those funds will enable the program to get of to a good start. It's obviously not the amount that we originally requested, but it will allow us to keep activities at the Centers on track, and will enable us to get the development contractors up and running.

"I don't think people outside Washington realize how difficult it was to get a commitment of over $500 million in this fiscal year for the Space Station when you consider that reducing the deficit is the number one priority in both the Administration and the Congress. Serious consideration was given to not funding Space Station at all this year," said Stofan. "The reason that we got that commitment is because the Administration and the Congress recognize that the Space Station is a key for the United States to be able to maintain, and in some areas regain, its leadership position in the exploration and utilization space.

"Because of the reductions, we are going to have to make some changes in the schedule, and the development contractors will have to adjust their activities to meet the lower budget. But I believe we have defined the right Space Station for this country, and we won't sacrifice quality or capability for schedule. We may do it slower, but we'll do it right, and I'm confident of our ability to step up to this enormous challenge and get this project going despite the obstacles.

"We have made significant progress this past year. While getting the C/D contracts awarded got the most attention, we also established the Program Office in Reston, which included getting that facility outfitted and operating, and awarded some major contracts, like the Technical and Management Information System, the Software Support Environment and the Program Support Contract, which lay the technical foundation for the development activities, and FTS Phase B. An extensive review by a committee of the National Research Council validated the baseline configuration for the Space Station, and I believe we have the team, and the momentum, to get this program moving and well in the way to establishing a permanent research facility in space by the mid 1990's.

Marshall Space Station Office Turns Focus to Future Milestones

With the long-awaited contractor selection announcement behind them, personnel in the Marshall Center's Space Station Projects Office have now turned their attention to key milestones necessary for accomplishment of Marshall's portion of the effort, known as Work Package One.

The negotiations on contractual terms are expected to result in the award of a definitized contract by mid-1988.

Meanwhile, a program requirements review is planned for the March-April timeframe of 1988. The review will establish the baseline from which all NASA centers involved in the project will begin preliminary design work.

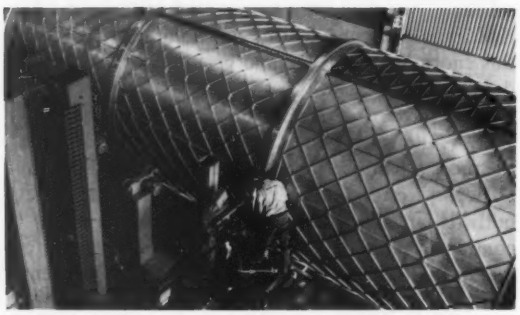
"No actual flight hardware will be produced that soon, but some full-size hardware items will be produced, even in the preliminary design phase," according to Beam. "Those items will be used in development testing and qualification of the design."

The preliminary design phase will culminate with a preliminary design review (PDR) in approximately February 1989. At that point, Space Station managers will review the results of the first year's effort, before giving a go-ahead for the critical design process.

For the next 18 months to two years, the design process will become increasingly detailed and specific, aimed at defining precisely what Marshall Center's elements of the project will look like. A vital milestone will be the critical design review (CDR), in which specifications and drawings—about 90 percent complete—are reviewed by project managers.

"In the CDR, we're essentially approving the design to be used for flight hardware. In doing so, we rely on things like development tests and hardware qualification results, so that we can be certain the hardware will meet program requirements," Beam said.

After completion of the CDR, the project will begin moving into production of flight hardware. First launch of station elements is expected by 1994, and will continue over a series of some 20 Space Shuttle flights.



A full-scale module structure, similar to one NASA plans to place in orbit in the 1990s as part of the U.S. Space Station at the NASA Marshall Space Flight Center Productivity Enhancement Center in Huntsville, Ala. The flight-quality space structure validates Space Station design, manufacturing and assembly processes and will be used for engineering evaluation and test. In this photo, a weld technician monitors the final weld as it is made to ensure that the weld torch accurately joins the Space Station prototype module seam.

Space Station means 1,000 area jobs for JSC

The Work Package 2, Phase 1, contract to be managed by JSC calls for McDonnell Douglas to provide the integrated truss structure, mobile servicing system transporter, airlock outfitting, resource node outfitting, hardware and software for the data management system, communications and tracking system, the guidance, navigation and control system, extravehicular activity systems, propulsion system, thermal control system and external attachment systems. JSC also will provide technical direction for the man-systems work being performed by Grumman Corp. for Marshall under Work Package 1, Covington said.

"We have a key part of the work to do," Covington said. "We have all the key subsystems except environmental control and power. We're responsible for putting together the design and what we call outfitting of the resource nodes, which is another name for the command and control element where the crew will work to run the Station."

McDonnell Douglas' proposed cost for Phase 1 is about $1.9 billion. Its proposed cost for the Phase 2 priced option is about $140 million. Proposed costs do not include fees or program reserves.

Major McDonnell Douglas subcontractors are IBM, Houston and Owego, N.Y.; Lockheed Missiles and Space Co., Houston and Sunnyvale, Calif.; RCA Corp., Camden, N.J.; Honeywell, Clearwater, Fla.; and Astro, Carpinteria, Calif.

The unsuccessful bidder for Work Package 2 was Rockwell International, with major subcontractors Grumman Corp., Bethpage, N.Y. and Houston;

Space Station proposals roll in
'It's not just paper anymore'

Contractor proposals for both Space Station options were delivered to Johnson Space Center and other NASA centers during July.

Mike Jordan, Space Station Marketing Manager for McDonnell Douglas, checks boxes off his list as van lines employee Ivory Cheeks wheels Space Station proposals out of a truck and into the Vanguard Bldg.

TRW, Redondo Beach, Calif.; Intermetrics, Huntington Beach, Calif.; Sperry Corp., Phoenix, Ariz.; Harris, Melbourne, Fla., and UTC, Arlington, Va.

"I feel like we were in sort of a win-win situation at JSC," Covington said. "We had two contractor teams bidding on this, both of which are very capable and experienced. Either one would do a credible job of doing the development work."

More than 2,000 contract employees will be working on Work Package 2 when the program peaks in two to three years, said Thompson, who was Space Shuttle program manager at JSC before joining McDonnell Douglas. Between 400 and 500 McDonnell Douglas employees and about 600 IBM, Lockheed, Honeywell and RCA employees will be located in Clear Lake, Thompson said. People from other programs will be added to the McDonnell Douglas personnel already here, and the rest will be new hires brought in for Space Station.

"A good percentage are new jobs to the area," Thompson said.

Roughly 1,000 people will work on detailed design and fabrication in Huntington Beach, he said.

Goddard Space Flight Center Will Manage

Work Package 3

NASA'S Goddard Space Flight Center is responsible for development of several of the Station's elements including the free-flying platforms and attached payload accommodations, and for planning NASA's role in satellite servicing. Goddard also has responsibility for developing the Flight Telerobotic Servicer which is being procured through a separate competition.

Free-Flying Platforms

Goddard will manage the detailed design, development, test and evaluation of the automated free-flying polar platform. This unmanned platform will feature modular construction to permit on-orbit ease of serviceability and flexibility for accommodating a variety of scientific observations.

Attached Payload Accommodations

The Space Station attached payloads are the instruments and experiments designed to gather scientific data while attached directly to the truss framework of the Space Station. Goddard is responsible for providing utilities such as power, thermal control, data handling, pointing stability and other equipment needed to operate the payloads and for insuring that the instruments are pointed at the intended targets. Two attachment points are provided, one of the attach points is fixed and the other has an aritculated pointing service.

Flight Telerobotic Servicer

Goddard is responsible for building the Flight Telerobotic Servicer. This system will be capable of in-space assembly of Station elements and payload servicing.

As the system is evolved, it will perform telerobotic servicing and repair of spacecraft visiting the Space Station. In the future, a telerobotic servicer-equipped Orbital Maneuvering Vehicle could retrieve, as well as service, spacecraft beyond the Space Station's orbit.

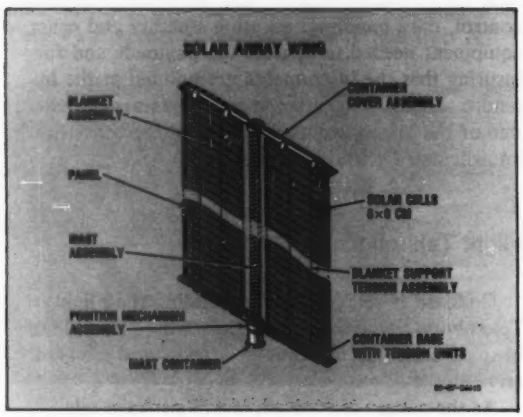
Lewis to Manage Space Station Contract Worth About $1 Billion

Lewis will be responsible for managing a multiyear contract with Rockwell International, Rocketdyne Division of Canoga Park, CA, worth approximately $1 billion. NASA has selected Rocketdyne for final negotiations leading to the award of a cost-plus-award fee contract for Space Station Work Package 4—the detailed design, development, test, evaluation, and construction of the electrical power system.

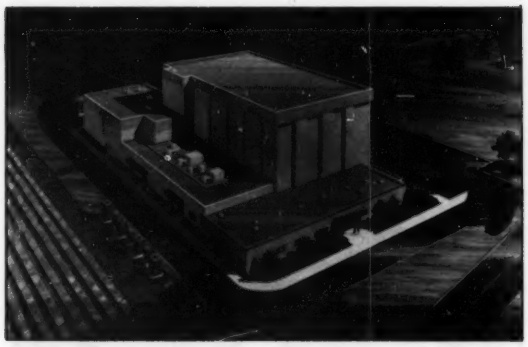
The power system will be used for the Space Station crew life support systems, experiments, communications, and data processing. The electrical power system is required to have the capability to deliver 75 kW of electrical power with a growth potential to 300 kW.

Initially, power for the Space Station will be provided by eight flexible, deployable solar array wings. This configuration minimizes crew involvement and takes advantage of technology demonstrated on a 1984 Shuttle mission.

In order to provide the power needed to assemble the Space Station, four solar wings and other elements of the power system will be on the first two of the 19 Shuttle flights planned to carry the components into space. These four wings will provide 37.5 kW of power.



Lewis is also responsible for developing and testing proof-of-concept hardware for the solar dynamic power module to prepare for Phase 2 of the Station. In addition, sufficient preliminary design efforts will be performed to insure that the Space Station can accommodate the solar dynamic modules.



NASA Lewis Research Center Power Systems Facility

To supply power to the Space Station during the eclipse period of each orbit, nickel-hydrogen ($Ni-H_2$) batteries will store the energy produced by the solar arrays.

Controlled power will be delivered to users throughout the Space Station by the 20 kHz power management and distribution (PMAD) systems. The high frequency ac power system provides high efficiency, low cost, and improved safety.

The performance and operation of the entire Space Station power system will be tested and validated in the Center's new Power Systems Facility, currently under construction in the West Area.

Rocketdyne was the sole offerer on the Work Package 4 contract.

Major subcontractors on the Rocketdyne team will be: Ford Aerospace and Communications Corp., Palo Alto, CA.; Harris Corp., Melbourne, FL; The Garrett Corp., Tempe, AZ; General Dynamics Corp., San Diego, CA; and Lockheed Missiles and Space Inc., Sunnyvale, CA.

Space Station Brings Challenge, Building to KSC

by KSC News Writers Beth Dickey

When NASA's space station heads for orbit, Kennedy Space Center will do more than provide the firepower. KSC will manage nationwide ground support for the program—a first.

That task is among several exciting challenges that KSC will face over the next three decades as America's manned presence soars from drawing boards permanently into space, according to KSC Project Manager C.M. Giesler.

Highlighting a long list of facility additions, Giesler said KSC will break ground for a space station processing building as early as this year model at least one Apollo-era structure for space station use, and modify both Shuttle launch pads.

Never before has KSC been responsible for designing, acquiring and providing all flight element transportation equipment to support a program. "Our main drive here is to try to bring out commonality, because there's a big payoff if we can do that," Giesler said.

He added that additional KSC responsibilities include managing two logistics functions for the space station: operational capability development (OCD) and logistics support analysis (LSA). These responsibilities fall under the Space Station Logistics Systems Office headed by Greg Opresko.

"OCD, simply put, is the responsibility to understand and implement all of the work package requirements and the user requirements as they exist at Kennedy—be they data bases or warehouses or whatever," Giesler explained. "In the case of LSA, we will organize and integrate individual work package analyses into something we can manage to ensure everything happens properly as the program progresses."

Final responsibility, Giesler said, is that the space station program has its own launch site Safety, Reliability and Quality Assurance Office, headed by Jim Lansing.

The responsibilities have been added to a pair of tasks KSC regularly performs—hardware design assistance and launch pad processing here and at California's Vandenberg Air Force Base.

"The bottom lines of all those responsibilities says that KSC's plate is going to be real full," Giesler observed. "We're really happy about that. It's quite a challenge."

Construction of a $64 million facility to house flight hardware assembly and processing operations at KSC is planned.

The building would be ready to occupy in early 1990. Validation of ground support equipment would begin in 1991, and the facility would be ready to receive and process flight hardware in 1992.

"We see that first flow processing being about a year in length, with a first launch in the mid 90's and some 18 months later, getting to PMC or permanent manned capability," Giesler predicted. He said the time schedules are likely to change, but the construction specifications will remain the same.

The building will have a total area of 265,000 square feet and contain one high bay measuring 46,000 square feet with a hook height of 50 feet. The facility will be situated immediately east of the O&C Building.

Space Station facility at KSC

Construction completion date sheduled for July 1991 (Activation date is March 1992)

Square footage approx. 264,000

Cost—in excess of $50 million

Jobs—creation of approx. 825 new positions by 1991

Langley has Key Role in Space Station Program

The Langley Research Center, through its Space Station Office headed by W. Ray Hook, is providing key technological and engineering support to the Space Station program. Center researchers and engineers are developing the technologies that will be incorporated into the initial Station and will improve the performance and capabilities of the evolving Space Station.

Langley is providing support in four broad areas. The first is Systems Engineering and Integration (SE&I) support to Level II through the performance of discipline analyses, system and subsystem trade studies and design studies. The second is Level I support with a broad responsibility for the definition of Space Station evolution. The third support area is as the focal point at Langley for technology development related to the Space Station. The fourth—and potentially most significant area—is as integrator, advocate and lead center in representing engineering users of the Space Station for technological experiments.

Langley's Space Station Office is composed of three offices:

1. The Evolutionary Definition Office, which has the job of identifying the systems capabilities which will be required to meet future Space Station mission needs; integration of study results into an overall growth plan, definition of growth of evolution concepts for the Space station; and establishment of technology needs for the most effective and productive evolution of the Space Station.

2. The Systems Engineering and Integration Office, provides support to the Level II program office in its systems engineering and integration work. This office also supports the Evolutionary Definition Office in systems analyses and concept development for Space Station evolution.

3. The Technology office, representing the engineering community that will use the Space Station for technological experiments. It provides technology and development support to Goddard, Marshall, Johnson and Lewis in the performance of their Level III Space Station assignments. Support is provided in the areas of Langley expertise: structures, dynamics, materials, controls, data management, communications, automation/robotics, and computer-aided engineering.

Langley has a broad responsibility for defining the growth direction of the Space Station and for the technologies to make that growth possible. The Space Station is expected to be a live-in facility for scientific research, commercial product development and space technology development.

The finished Space Station will be an investigative facility. The continuous presence of six to eight specialists will allow extensive experiments that previously could not be performed. Earlier space experiments had to be completed in a few days—sometimes much less time than necessary—or be run completely by machine, with no assistance from the people who developed them. This led to an unfortunate problem: operations that were done too quickly were not always accurate, and ones left to run on unmanned missions were difficult to repair and restart if they failed. In the Space Station, astronauts and specialists will be able to make adjustments in instruments without returning them to Earth, so tests can be performed with little or no mishaps. Consultations with colleagues on Earth will also be possible, via radio and television. This aspect should further improve operations and test results.

NSTL Promotes Commercial Participation in Station

The Space Station assignments at NSTL are being carried out by the Earth Resources Laboratory, the installation's research and development organization.

NSTL has conducted NASA outreach activities designed to inform, stimulate, encourage and facilitate U.S. industrial participation in NASA programs. In this effort, an information base developed at NSTL is used to provide technical assessments to U.S. industry regarding commercial remote sensing opportunities on Space Station.

A major portion of NSTL's outreach activity was preparation for the Space Station User Workshop held in Nashville, Tenn., in November 1987. Sponsored by the Office of Space Station and the Office of Commercial Programs, the industry-oriented workshop was organized to elicit U.S. industry requirements in their anticipated utilization of the station.

One of the potential activities proposed for implementation on Space Station was the Remote Sensing Test, Development, and Verification Facil-

ity. The facility was defined and evaluated at NSTL on the basis of user input from workshops and outreach activities. NSTL will conceptualize and design the facility as a Space Station payload.

NSTL supports and chairs the Commercial Earth and Ocean Observation Working Group, which advocates and perpetuates the incorporation of commercial remote sensing users of the Space Station.

The Space Station Payload Stimulator is a software package written entirely in the Ada programming language that supports Space Station program activities. The simulator, developed and maintained at NSTL, presently resides on computer systems at the Johnson Space Center, Goddard Space Flight Center and NSTL.

Space Station and Commercial Programs

Space Station: 2 Mods, Earth vu.

KSC Newswriter

by Pat Phillips

NASA hung out the "space for rent" sign in Nashville, Tenn., Nov. 3-5, and more than 240 potential commercial users of the space station came to appraise the space-age property in a spirited workshop attended by top NASA management, high-level industry executives, and four astronauts.

In three days packed with presentations, working panels and brainstorming sessions, NASA officials carried the message to the international business community: plan now to fly later.

The space station will "provide access to space like we've never seen before," declared Andrew J. Stofan, NASA associate administrator for the Office of Space Station.

Saying that there would be a "minimum of five space shuttle flights per year to the space station, loaded with gear, people, and experiments," Stofan said that the station "provides an opportunity for entrepreneurs" and will be a "place of business."

"Visualize where you're going . . . look at it phase by phase," challenged James T. Rose, NASA assistant administrator in the Office of Commercial Programs. Rose, in his first major conference since his Oct. 5 appointment, declared NASA's commitment to commercialization efforts.

Rose told the gathering that NASA's Commercial Programs Office look forward to hearing from you, to hearing your needs. If I were in your place, I'd be thinking ahead about what kind of research for my company, and what kind of support I would need to achieve," declared Rose, who came to NASA from McDonnel Douglas Astronautics, where he helped pioneer industrial space manufacturing as head of the company's Electrophoresis Operations in Space.

Discussing the cycles that business must go through in order to effectively move from idea to implementation, Rose pointed to the track record established by some early entrants in commercial payloads, such as 3M Corp., which will again fly with NASA with a payload aboard Discovery during the STS-26 mission scheduled for June 1988.

Dr. Chris Podsiadly, director of 3M's Science Research Laboratory, attended the conference to give other managers the benefit of "hands on" experience with NASA commercial in-flight experience. His pragmatic approach addressed a key business issue: dollars and cents.

"You have to think ahead. What do you say when you step in front of the vice president of the organization and tell him how you're spending your research dollar . . . and what you intend to develop?" Podsiadly said.

He cautioned that "just as it takes time for an idea to get from conception to the marketplace," it takes time to develop an idea and receive NASA payload allocation space. The planning and management of that process is critical to successful commercial applications in space, Podsiadly believes.

"You start with your science base, you get the date, you build that up. Then you begin to build your technology. Then you lok again, and see that it looks pretty good, and that at the end, you think you'll have a product, and that it will sell," Podsiadly said. He added frankly, "right now, many of you are at step one—compiling the knowledge. And that's good. We're sharing in a golden era. Together, we can build quite a store of knowledge."

"A National Resource, An International Enterprise"

The following is an excerpt from an interview with Al Diaz, assitant associate administrator for Space Science and Applications for Space Station.

NASA is making a conscious effort to recognize that the Space Station is number one, a national resource and number two, an international enterprise.

The implications are profound. In a sense, the science utilization of the Space Station from a national perspective is bigger than NASA. We fully expect that other government agencies like NIH, NSF, USDA, the Department of Energy, NOAA, and among others, National Bureau of Standards, will have a keen interest in using the Space Station and so we're trying to develop mechanisms to have them involved in our planning process so that we can act as their agents in trying to influence the design of the Space Station from a national perspective.

We also recognize that, assuming that things go well with the negotiations, we will be cohabitating in the Japanese and the European modules with international scientists. So we'll have three connected modules up there, the utilization of which ought to be optimum.

Despite the fact that there are other national interests that need to be served by each of the partners, there are also international science interests. There are areas of science that have traditionally been international, space physics being a good example. Earth sciences, another example. They are all international in flavor, and so we need to develop mechanisms for international planning of the utilization of the Space Station.

The complexity of the science utilization job is compounded by the national and international dimensions of the Space Station much more so than Space Lab was, much more so than the utilization of the Space Shuttle was.

We firmly believe that that national and international planning has to be part of the initial process that is involved in the design and development of the Space Station.

Canada will provide a mobile servicing system (MSS)

Negotiators from NASA and the Canadian Ministry of State for Science and Technology (MOSST) reached agreement in December on the text of a memorandum of understanding (MOU) for cooperation in the detailed design, development, operation and utilization of the permanently manned, civil Space Station.

In the next step negotiators on both sides will submit the MOU text to their respective governments for consideration. In Canada, approval of the Cabinet is required. In the U.S., the agreement will be reviewed by both the Executive Branch and the Congress.

Canadian participation in the Space Station program resulted from an invitation issued by President Ronald Reagan in 1984 to Canadian Prime Minister Brian Mulroney. NASA and Canada entered into an MOU for the definition and preliminary design phase of the Space Station program in April 1985 and the two agencies have been working together in the design phase of the program since that time.

Under terms of the MOU, Canada will provide a mobile servicing system (MSS) to the international Space Station complex. The MSS, an essential part of the Space Station program, will be used in conjunction with the assembly, maintenance and servicing of Space Station elements. In exchange, Canada will participate in the management and operation of the Station, and Canadian users will be able to use the full range of capabilities provided on the permanently manned Space Station.

Cooperation in the international Space Station complex is the culmination of more than a quarter century of U.S.-Canadian cooperation in space programs. Over 25 years ago, the first Canadian satellite—Alouette—was placed in orbit on a NASA launch vehicle. In the ensuing years, a series of follow-on communications research projects and a variety of scientific collaborative efforts have furthered the U.S.-Canadian space relationship. The most ambitious cooperative project to date between the two nations has been the Canadian contribution of the remote manipulator system, or "Canadarm," to the Space Shuttle program.

Space Station and Education: Partners for the Future

Our nation's youth are learning about space and preparing for the future.

Students from kindergarten through high school are beginning to learn about the potential of space through activities as diverse as building space station structural elements out of drinking straws to conducting small scale lab experiments in electrolysis to demonstrate how oxygen might be produced in space.

Students build Space Station laboratory mock-up

Virginia Students Build Space Station Bays

The spirit of pioneers and explorers lives on in the students of Hampton, Virginia. Sixteen students from Cooperating Hampton Roads Organization for Minorities in Engineering (CHROME) tackled the challenge of space at the NASA Langley Visitor Center in December.

The high school students from area schools were selected by essay completion and were afforded "the opportunity to learn firsthand the variety of professions available in high technology" in a two-day aerospace workshop, according to Dr. Lillian Meyers, Director of CHROME.

The Virginia Students toured the NASA Langley structures laboratory for a demonstration of new structures for the Space Station. They experimented with computer programs highlighting the Space Station and Space Shuttle. To cap off the workshop, students built Space Station bays as they may be built in space during the next decade.

Teachers are coordinating a variety of Space Station projects to motivate students in the areas of science and mathematics. In Louisiana, Teacher in Space, Deborah Harris is working with students on simulated missions using Space Station modules.

One very special Space Station module built by high school students in Shreveport, Louisiana attracted up to 1,700 visitors a day while on display at the Children's Exploratorium.

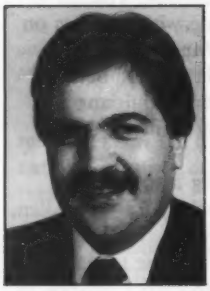
Under the direction of drafting instructor, Dominick Tuminello and art teacher, Edward Allen, high school students from Caddo Magnet High School participated in a 30 day exercise to design and construct a Space Station laboratory module 16 feet long and 8 feet in diameter. The lab module is one of only three existing Space Station mock-ups.

The students spent the first 10 days developing their design, and the next 20 constructing an octagonal wooden frame covered with a .032 guage aluminum skin and held in place with aluminum ribs. The eight-sided design was chosen on the basis of the maximum area and structural support provided by an octagonal shape. The student design incorporates forty ribs and 5 bulkheads (8 ribs per bulkhead). After partial construction at the school, the module was moved to the Exploratorium for completion. The module was later moved to more permanent quarters in a local airport hanger where eventually a mobile home will be attached so that "research missions" may be conducted day and night.

The educational project was sponsored by NASA's regional Teacher Resource Center at Bossier Parrish Community College in Bossier City, Louisiana under the direction of Deborah (Debo) Harris, Louisiana's Teacher in Space, and Director of NASA's regional Teacher Resource Center in Louisiana.

The NASA Teacher Resource Center Network is a dissemination mechanism for educators. Teacher can acquire a wealth of information generated by NASA programs, technologies, and discoveries to use in the classroom. The intent of these NASA educational materials is to stimulate student interest in science, mathematics, and other disciplines through the excitement of NASA research programs. A Teacher Resource Center is located at each NASA field center, with 17 located across the country in selected museums and universities. The NASA Educational Affairs Division's five year plan is to have at least one Teacher Resource Center in each state.

The Office of Space Science and Applications for the Space Station



Al Diaz spends 100 percent of his time working on issues related to space science on the Space Station and activities associated with getting there. The assistant associate administrator for space science and applications for the Space Station since October 1987, Diaz put in over 20 years with space science programs and a year in the Space Station office before commencing to organize activities within OSSA order to best take advantage of Space Station.

All of his experiences at NASA lend to Diaz's current position working with space science and Space Station where he says, "I enjoy being in the position where I'm a trusted member of both staffs."

Working in a Volatile Environment

Al Diaz characterizes the environment and the conditions under which he works as "volatile"—not hostile, but definitely volatile. He says, "there's a lot of change in attitudes and there's a lot of change in programs. The Space Station configuration has been changing and I see a very clear transition in people's attitudes about Space Station utilization. There is more and more interest in the effective utilization of Space Station."

Diaz's response to the "volatile" environment in which he works is to be flexible. He says, "there are very few things that we are holding sacrosanct. There are very few things that we've said must be a certain way. Among those are OSSA's strategic plan and science traditions. We're trying not to interfere with the traditional space science approaches that have evolved to date when those traditional approaches are more appropriate to the specific mission."

Working Within an Overall OSSA Strategy

Diaz says, "the Office of Space Science and Applications' overall strategy involves identification, advocacy and implementation of science programs and to the extent that the Space Station fits within the context of those science programs, the Space Station is viewed as an appropriate way to do science. To the extent that it doesn't," Diaz says, "we don't want it competing with the alternative traditional ways of doing space science."

Al Diaz strongly believes that "the utilization of the Space Station from a sciences and applications standpoint, should never develop a life of its own." According to Diaz, "it should always be kept in context that the Space Station should to be used for science and applications when it is most appropriate."

Working to support this general strategy, it is Diaz's responsibility to conduct strategic planning and to "get an understanding of what the individual OSSA discipline division interests are in utilizing the Space Station."

If You're a Scientist, How Do You Get to Use the Space Station?

When a scientist asks, "If I have an idea for using the Space Station, how do I present this idea?"—Al Diaz is responsible is for making sure that his or her question is answered.

Diaz says that it is his "ultimate hope" that the way a scientist gets to use the Space Station is "virtually identical to the way they get to use any other piece of equipment NASA develops . . . so that it will be consistent with space science traditions."

"As an example, when an announcement of opportunity goes out, we want to make sure that the proposals are to do science and that science is purely viewed as a first order of business. In addition to that, the suitability of the Space Station for that science should be part of the process in deciding whether or not to accept the proposal. We don't want to convey to our community that in any way Space Station is out to distort their science planning. Rather Space Station should enhance their capability to do science.

A Space Station Science Utilization Management Plan

Diaz currently is working to develop a Space Station Science Utilization Management Plan that will address the issues related to science utilization of the Space Station.

"For instance," Diaz explains, "we will be considering how to deal with experiments inside the pressurized module, experiments on the polar platform or co-orbiting platform and experiments attached to the manned base."

The Space Station Utilization Management Plan will address how experiments will be solicited and developed, how missions will be defined and managed and what will be done with data the collected.

Acknowledging that "like most things on the Space Station, science utilization is a difficult management task because there are a lot of people involved and a lot of different organizations." Diaz emphasizes that the plan will take into consideration past OSSA traditions, and to the extent possible, each of the science disciplines will be allowed to "operate within the cultures that have developed."

Science Users on Space Station: Three Classes of Experiments

"In every discipline there are science missions that are better suited for use on the Space Station than on other platforms."

In the Pressurized Module

"The pressurized module is absolutely enabling to the microgravity sciences in material sciences and life sciences."

Taking into account past OSSA experience, the dominant users of the pressurized module will be life science and materials science users.

On the Polar Platform

"Clearly, the polar platform is ideally suited for the earth observing system.

"The polar platform will be dominated by the earth observing system, which is the first step toward fulfillment of the objectives of Mission to the Planet Earth." Diaz says that there also may be some space physics experiments on the polar platform, yet to be determined, that would deal with sensing the environment in space.

In the Attached Payloads

"In the case of attached payloads, the opportunity represented is not an enabling one, but it's an enhancing one. Clearly we could always fly free flyers, but the one thing that the Space Station does provide us with, in terms of the attached payloads, is the capability to service and to interact with the payloads."

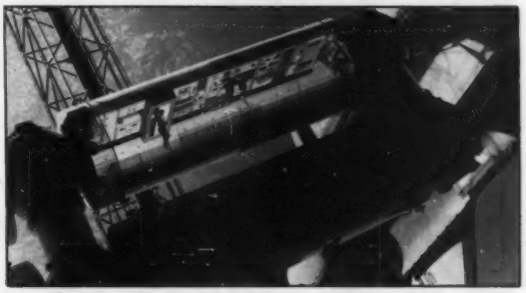
In the attached payloads, "virtually every science discipline" will be represented. As an example Diaz noted, "we have planetary interest in cosmic dust collection. Scientists hope to use the Space Station as a base for the collection of that material."

"In Earth sciences, the hope is that we'll be able to use the Space Station as an attachment for instruments like the Earth radiation budget experiment, the laser atmospheric wind sounder, and the tropical rainfall measurement mission, which will provide the capability to continuously monitor rainfall in the equatorial regions of the Earth.

The Process

Once the planning phase for science utilization of Space Station is completed, the process begins.

"We are beginning a very big activity right now that is key to the start of the Space Station Phase C/D contracts," says Diaz. Steps have already been taken to begin definition studies on instruments for platforms and attached payloads. Definition work is also planned for a space biology payload for Space Station. An Announcement of Opportunity for earth observing systems, expected to dominate the polar platform utilization, has already been released this year. Also, the preliminary requirements review (PRR) process will begin. The PRR will validate existing Space Station requirement documents which will, in turn, become the development requirements eventually given to NASA's contractors.



A cutaway view of the inside of the materials processing laboratory, one of two U.S. modules that are part of the baseline configuration for the permanently manned Space Station, shows crewmembers working inside the 13.6 meter (44.5 foot) long module in shirt-sleeve comfort. Meanwhile, two other space suited crewmembers are shown performing repairs on the outside of the other module. Space Shuttle Discovery is shown docked to one of the external node/tunnel components which link the modules. Placing interconnects outside of the modules affords more volume for locating scientific instruments inside. Each U.S. module provides more than 185 cubic meters of useful volume. This artist concept was done by Boeing Aerospace Company, Seattle, WA.

Al Diaz began his NASA career as a co-op student at the Langley Research Center. Diaz's professional experiences in space science programs date back to 1966, as a science researcher at Langley. Diaz spent 5 years as a researcher at Langley before moving onto NASA Headquarters to work on the Viking project. It was for his work on Viking that he was awarded NASA medal for Outstanding Scientific Achievement. In 1979, Diaz moved to Headquarters to spend the next 6 years in OSSA's Planetary Division. A space scientist by training, Diaz was awarded the prestigious Sloan Fellowship at MIT in 1985 to do advanced study in strategic planning. Following completion of his dissertation on strategic management of the Space Station, Diaz worked for a year in the Space Station office.

Dr. Frank Martin, deputy associate administrator for Space Station, ***explains Space Station design to junior high school students in Washington, D.C. during National Education Week.***

Spreading the Word

Associate Administrator for Space Station, Andrew Stofan explains model of Station to Gov. Baliles of Va. Deputy AA Thomas Moser looks on.

Welcome to Reston! Deputy Associate Administrator for Space Station, Thomas Moser sits in his new office. He says; "it's new, it's nice and it's adequate."

A small, humble workplace.

The Space Station program office is housed in an sprawling, three-story red brick building with skylit interiors. The building rests on a scenic in ridge Reston, Virginia.

The Reston Program Office has been designated "a part of headquarters" by the NASA Administrator. In choosing a site for their quarters, the Space Station Program Office was required to move no closer than 15 minutes and no farther than 45 minutes from Headquarters. The site chosen was 30 minutes from headquarters and only 8 miles from Dulles airport.

The new facility will eventually house between 375 to 400 people. The Reston facility currently enjoys almost 40% occupancy.

While all individual office spaces are ready for occupancy, work still needs to be completed on the many conference rooms, the videoconferencing center, and management and information center.

Vending machines, a credit union, a travel service, and an imprest fund will round out the other support facilities that will be available to Space Station program office employees.

The Office of Space Flight/Space Station Integration

The office of Space Flight/Space Station Integration, (SFSSI) is responsible for developing any space transportation and related capabilities necessary to support the Space Station. The office is also responsible for informing the Space Station office of what the current space transportation capabilities are so that design work on the Space Station will fit those capabilities.

Former SF/SSI Director E. William Land says he divided his time almost equally between the two offices. "I spent a lot of time with the Space Station people in order to understand what their problems are, and I spent about the same amount of time with our own people trying to figure out what our problems are with the Space Station."

While Land felt that initially he was looked upon as an outsider by people in the Space Station office, he says the feeling has long since passed and especially in the last year "it's really come to be a team effort."

A cross between a "traffic cop" and a catalyst, Land says that "more has been accomplished in the last six months to a year in the working together of these programs and bringing them together than had been done in all the time prior to that. There had been some missing links between the two programs. . . We had to integrate the two programs, and I think every major problem we have encountered has been fixed in the last year."

The NASA Space Station Transportation Report; Major Breakthroughs in Shuttle/ Station Integration

Last year the office of Space Flight/Space Station Integration participated in a joint study with Space Station program office with OSSA's Life Sciences office to determine how to configure the Space Station assembly process and the longer term operational logistics process to be able to fit within the capabilities and limitations of the transportation system."

The results of this study have been compiled into a report for Congress entitled *The NASA Space Station Transportation Report*. According to the report delivered to Congress in mid-January, the study yielded several interesting results.

A Decrease in the Required Flight Rate

Land says, "we had generally assumed we were going to fly eight or so shuttle flights a year to support the Space Station. It became clear that eight flights per year, after the Challenger, was going to be extremely difficult to support." Such a shuttle flight rate dedicated to the Space Station would have taken "a huge share of this capacity" and reduced flexibility in the face of a newly revised shuttle schedule of up to about 14 flights a year.

The report concluded that during the Space Station's three year assembly phase, only five to seven Shuttle flights would be required a year." After the assembly phase, Land says, the study concluded "that we could satisfy the requirements of the Space Station as we know it with a sustained rate of no more than five shuttle flights a year."

A Reduction in Crew Rotation Demand

"The biggest breakthrough we had in reducing the number of flights was in the life sciences area where they had been expecting to stay within the existing U.S. experience base and remain only 90 days per crew on orbit."

The study found that 180 crew days on orbit would be more practical in terms of "the best use of the resources: the best use of the Shuttle, the best use of the people, and the best use of the Space Station.

Land explains, "the Shuttle is the only capability that we've got to get the crew up and down." With the increase in the number of days a Space Station crew could remain in orbit, the number of Shuttle flights required to rotate crews could be cut in half.

Increased Shuttle Landing Weight

Increased Shuttle downweight capacity was another "breakthrough." As the result of an ongoing structural analysis and additional review of forces encountered by the Shuttle orbiter during maneuvers shortly before landing, it was determined that the allowable end-of-mission landing weight for Shuttle orbiters could be increased to 230,000 pounds from the previous 211,000 pounds.

Rear Admiral Richard H. Truly, associate administrator for space flight, announced in November 1987, "Our initial analysis indicates that this change will allow the Space Shuttle to carry a cumulative weight in excess of 100,000 pounds of additional payloads into orbit through 1993. The additional downweight capability also will provide an important balance between delivery and return cargoes at the Space Station orbit of 220 nautical miles."

Possible Future Improvements

ASRM

A future enhancement in Shuttle/Space Station integration may come if Congress agrees to fund development and qualification of the Advanced Solid Rocket Motor (ASRM). The ASRM is planned to provide a necessary upgrade to the long-term safety, reliability, and performance capability of the Shuttle, and would have major advantages for the Space Station as well.

Land says, an "area that we looked at very hard was ascent performance, how many pounds can we take into orbit? Prior to the study, we had anticipated taking roughly 40,000 pounds to orbit for the Space Station . . .in high orbit. The study, however, pointed out advantages to station assembly manifesting that would accrue from greater Shuttle performance, and those advantages became the major influence on a performance goal for the ASRM."

Five definition studies for an ASRM design are currently in progress. Upon completion of the studies in April 1988, competitive procurements for selection of a propulsion contractor to design and develop the ASRM could begin if funds are appropriated by Congress. With the ASRM, the Shuttle could carry up to an additional 12,000 pounds of payload.

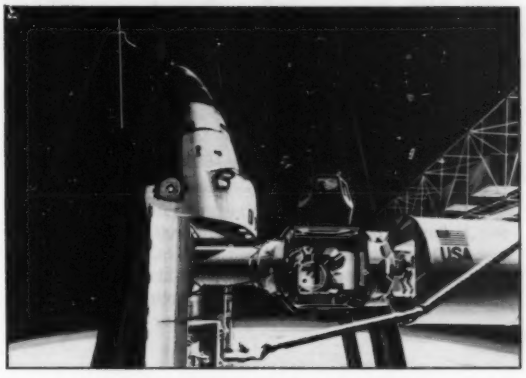
Increased Passenger Capacity

Land's office also is working on a study that will look at ways to modify the Shuttle cabin so that the number of Space Station crew members on a Shuttle flight can be increased. Right now the plan is to carry four passengers to the Space Station and bring four back. "The study is looking at carrying more Space Station passengers such that we could exchange five or six, maybe, at a time."

Shuttle/Station Integration Projects

In addition to identifying advances in terms of more efficient and effective ways to integrate Shuttle and Space Station operations, the office of Shuttle/Station Integration is also responsible for several other integration projects.

One obvious Space Shuttle/Space Station Integration requirement that the office of Space Flight/Space Station Integration is responsible for is a docking module. The SF/SSI office is working with the National Space Transportation office and its people at the Johnson Space Center to develop a Shuttle docking system capable of attaching to the Space Station's large mass "to allow for the transfer of people through a pressurized tunnel so that they can go from the pressurized cabin of the Shuttle to the pressurized environment of the Space Station without having to put on space suits."



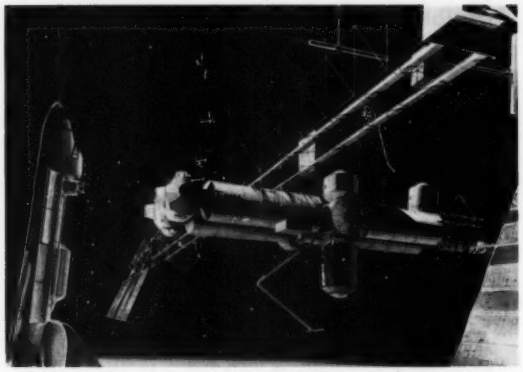
A closeup view of the Space Shuttle docked to the permanently manned Space Station. The Shuttle is docked to a pressuriezed resource nodes which permits crew members and equipment to be transferred from the Shuttle Station. The resource nodes connect the pressurized laboratory and habitation modules, and house command and control equipment. To the right of the resource node, a station crewman operates an experiment in the United States laboratory module. Above the resource node is a cupola, which affords a 360-degree view to aid in Shuttle docking activities. Also shown in the picture is the Canadian-built remote manipulator arm which will assist in the assembly and maintenance of the Space Station. One set of photo-voltaic solar arrays can be seen in the background of the drawing.

Perhaps a less obvious integration requirement is the need to modify the Shuttle's remote manipulator arm system so that it may be used a back-up docking system for the Space Station. Land explains, "with the docking system you just drive the Shuttle into the Space Station and the two meet and they latch up. If that, for some reason, were not to work we would still want to get the two vehicles together." In a manual docking, the remote manipulator arm would be capable of grappling the two vehicles. Currently the arm handle weights up to 65,000 pounds. In order to handle the weight of the Shuttle in a manual docking maneuver the arm would have to be able to handle more than 200,000 pounds.

The office of Space Flight/Space Station Integration is also working on developing a payload deployment system that "would allow us to take Space Station assembly cargo to orbit without the

manipulator arm." Land explains, "the arm weighs 1,100 pounds, take it off, you can carry 1,100 pounds more weight to orbit." By developing an alternative to the arm that would weigh as little as 200 pounds, available cargo weight available would be increased.

E. William Land, Jr. works in the Office of Space Flight as the Director of Space Flight/Space Station Integration. While Land officially undertook this position in June 1987, he estimates that he has been interfacing with space station and trying to integrate the two programs for about three years. Land has worked in the Office of Space Flight since 1965.



Phase 1 of the permanently manned Space Station focuses on the four pressurized modules that will be the hub of activity for the 8-member crew on the orbital research center. The modules are connected by four "resource" nodes which also house Space Station command and control subsystems. The two modules closest to the approaching Space Shuttle orbiter are the U.S. provided laboratory and habitation modules. The Japanese Experiment Module, with its own manipulator arm, experiment resources module and exposed work decks, is clearly visible in the right foreground. Nearly hidden behind the Japanese module is the European Space Agency laboratory module. A single logistics module, the supply room for the Space Station, sits underneath the working and living modules. Above the logistics module is one of two Space Station airlocks which permit space suited crewmembers to work outside the pressurized environment of the Station.

Code R Involvement in the Space Station

Judith Ambrus is the Acting Assistant Director for Large Space Structures within the Space Directorate of NASA's Office of Aeronautics and Space Technology (OAST). For the past three years OAST has been involved with the Space Station through its office of Space Station Technology.

The primary role of the Office of Aeronautics and Space Technology (OAST) in space research is to provide technologies that will enable/enhance future space missions.

The Office of Aeronautics and Space Technology has been developing advanced concepts in the various discipline areas that relate to Space Station. Examples include large area, flexible solar arrays, large capacity heat pipes, and erectable structures. Once Space Station started into the Phase B process with the accompanying Advance Development program some of these technologies were transitioned into that program with OAST starting into new areas for missions beyond Space Station.

The interactions of the Office of Aeronautics and Space Technology with Space Station are twofold:

- OAST develops technologies that might be used on evolutionary space station operations. The primary example of this involvement is the large automation and robotics program designed for this purpose. OAST also works closely with OSS to define a synergistic advanced development program and to respond to technology requirements as evolutionary space station becomes better defined.
- OAST plans to become a major user of Space Station for technology development experiments. Using the space environment for some experiments is not new to OAST; it is evident, however, that enabling future missions will require many space based experiments and feasibility demonstrations in key technology areas. Therefore the use of this unique facility is an integral part of OAST's strategic planning.

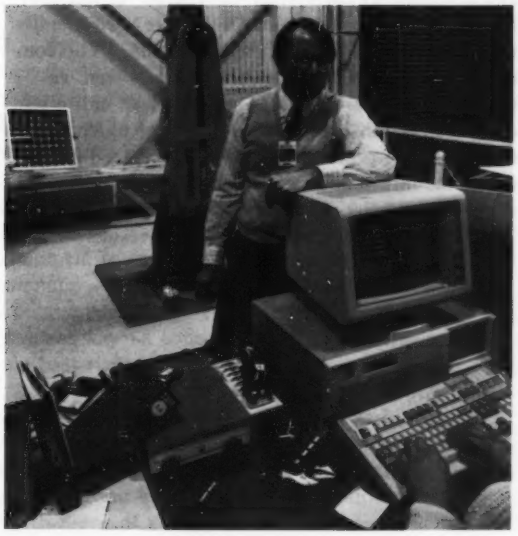
Space Station and New Technology

A space robot or Flight Telerobotic Servicer (FTS) will be launched on the first Space Station assembly flight.

Managed by NASA's Goddard Space Flight Center, Greenbelt, Md., the FTS will allow robotic in-space assembly of Station elements and payload servicing. The FTS is slated to be launched on the first Space Station assembly flight. Initially, the FTS will be capable of performing such diverse tasks as installing and removing truss members, installing fixtures on the truss, changing out Space Station orbital replacement units, mating thermal utility connectors and performing inspection tasks. The FTS also will enhance crew safety and productivity by reducing extravehicular time, using robots for hazardous tasks and freeing crewmembers from routine tasks.

As the system is evolved, it will perform telerobotic servicing and repair of spacecraft visiting the Space Station. In the future, an FTS-equipped Orbital Maneuvering Vehicle could retrieve, as well as service, spacecraft beyond the Space Station's orbit.

NASA selected Grumman Space Systems, Bethpage, N.Y., and Martin Marietta Astronautics Group, Denver, Colo. for negotiations leading to the award of parallel, firm-fixed-price contracts for definition and preliminary design (Phase B) studies of the Space Station Flight Telerobotic Servicer (FTS).



Duane Johnson tests his six-degree-of-freedom hand controlling system. The Space Shuttles remote manipulator system (RMS) utilized two three-degree-of-freedom hand controllers, one for rotation and another for translation. A six-degree-of-freedom hand controller would enable a Space Station crew member to control both translation and rotation of a remote manipulator with just one hand controller.

The FTS will be a space robot with automated features that will assist crews in the assembly, maintenance and servicing of the Space Station and visiting spacecraft.

The nine month contract studies valued at $1.5 million each are being performed at the contractors' facilities.

In their studies, the contractors are analyzing and evaluating various design concepts for the FTS, as well as the areas of robot configuration, the workstation, software and the FTS-to-Station interface requirements.

A key element of the Space Station program, the FTS will employ technology not used on previous NASA spacecraft. Robotics technologies developed in the FTS program are expected to have terrestrial applications and will play a role in enhancing the United States' industrial competitive posture worldwide.

Don Barron stands in front of the compound robot he is developing at JSC. The compound robot is made up of one large industrial robot and two small industrial robots, and is designed to study the interfaces and controls needed to operate such symbiotic devices. The compound robot could be an extremely crude forerunner to future Space automation.

Greg Blackburn, Systems Development and Simulaton Division, demonstrates the OMIS in the Space Station command and control center mockup scanning the small OMIS display screen..

OMIS: A lot of information in a small package

By JSC Newswriter Barbara Schwartz

The once voluminous procedures manual is small and compact, could easily fit in a briefcase, has no torn or dog-eared pages and presents its information in living color.

That at least is the potential for an information system now being evaluated by JSC for Space Station applications.

A miniature headband-mounted television monitor, (as well as a normal TV monitor), a voice-actuated computer system, and a laser disk library are the components of the system, known as the Operation and Maintenance Information System, or OMIS.

A key to the OMIS concept is the fact that more than 54,000 pages of information or pictures can be stored on a single 12-inch diameter laser disk, so vast amounts of information that normally would have to be transported to the Space Station in the form of bulky notebooks, blueprints and other materials could easily be carried in a briefcase.

The OMIS is seen as having the potential to be used as a reference library with repair and maintenance manuals, blueprints, other reading or reference material, and even an entertainment center with films and music.

Albert Wetterstroem, Space Station Advanced Development Office, said OMIS was developed by McDonnell-Douglas using existing technology as part of an Advanced Development Program contract. The design goal was to demonstrate the OMIS concept for astronauts' use both inside and outside the Space Station.

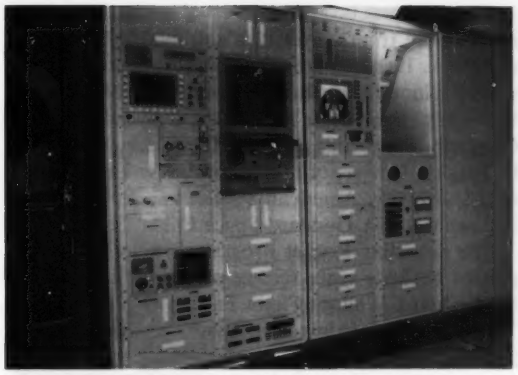
Crew members can use the normal TV monitor in a Space Station Module or an astronaut on EVA could use the mini-television monitor inside his or her helmet to receive exactly the same information on how to make repairs on Space Station equipment.

The OMIS equipment was delivered to the Crew Control Mockup (CCM) in the Systems Development and Simulation Division last August. Gregory Blackburn, an engineer in the CCM who is demonstrating and testing OMIS, said the system is for "brainstorming" for ideas on practical applications and improvements to both hardware and software.

The OMIS demonstration shows video of astronauts in training exercises in the underwater facility at McDonnell-Douglas, Huntington Beach, using various inflight maintenance tools for contingency operations. Conceivably, OMIS could replace many hours of training activities by having audio-visual instructions available for all potential onboard repair procedures.

"It is a very effective instruction system." Wetterstroem said. "You can have someone instructing you as they point to a picture or demonstrate the tool without tying up a large number of ground personnel."

A controlled test was conducted recently in the CCM using engineers as subjects. The purpose of the test was to get feedback from the future users and designers of the system on whether or not they found it helpful, how to make it more user-friendly, and suggestions for other improvements. "The comments were very favorable—the subjects were enthusiastic about the concept. Imagine, an entire set of Space Station maintenance manuals, blueprints, and operation procedures in one briefcase. Furthermore, the information is in color, live action is available, and the pages never get dirty or torn," Wetterstroem said, describing the test results.



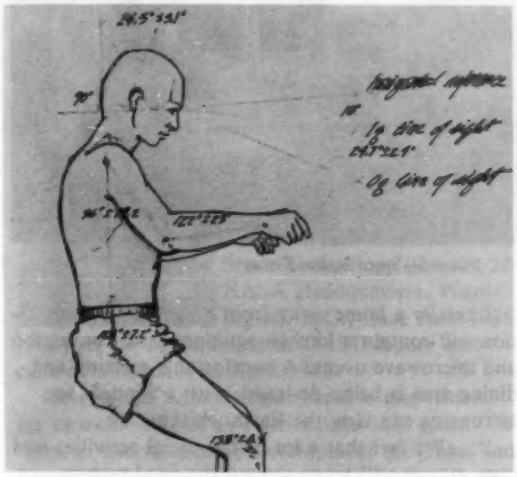
JSC Mockup—Space Station Health Maintenance Facility

Health Fitness Aboard the Space Station

While astronauts look like they're having fun enjoying head-over-heels freefall in space, it turns out that weightlessness can cause medical problems. According to Dr. James Logan, Chief of the medical operations branch at the NASA Johnson Space Center in Houston, Texas."The first major problem is cardiovascular deconditioning. In other words, the heart getting lazy. I think the second is probably skeletal muscle deconditioning. Your muscles actually get lazy. The third problem is probably the bone problem, the demineralization of the bone, because you lose calcium when you get exposed to zero-G."

To counter such medical maladies onboard the U.S. Space Station in the 1990s, NASA is reviewing such things as daily exercise programs using a stationary bicycle. An onboard pharmacy is also being designed as is a compact, computerized Health Maintenance Facility that could find use right here on Earth. This compact unit contains state-of-the-art diagnostic and therapeutic gear to perform astronaut health checks, including dental tools and equipment to carry out minor surgery. Tied to a computer system, the Health Maintenance Facility is a unique packaging of new technology in an innovative way—a concept that could provide important uses right back here on Earth.

"We are hoping that technology has application to all terrestrial medical settings," says Logan, "whether it is in an intensive care unit in major medical center or whether it is health care in a remote setting like an Indian reservation or on the North Slope of Alaska or an offshore oil rig or a nuclear submarine. We think it definitely has relevance to terrestrial medical care. We hope and we really believe there will be a lot of spin offs in that particular area."



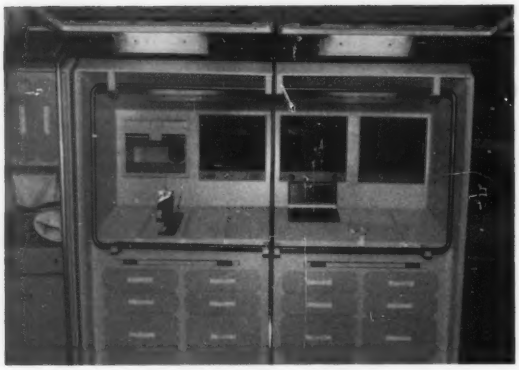
Neutral body posture. This shorts-clad fellow may not look it, but he's very relaxed. In fact, he is in what aerospace engineers call the neutral body posture, the posture that men and women naturally assume in gravity-free space. Engineers working on Boeing's Space Station concepts must design to this unearthly position when considering astronaut chairs, tables, work station, etc. Standard equipment of the sort found in our gravity-bound environment would be extremely tiring.

Food for the Space Station

A challenging task for planners in developing the U.S. Space Station for the mid-1990's is that of maintaining crew morale over the long tours of duty. One way is through the meals served to the Station's men and women astronauts.

Beverly Thurmond, the Space Station Food Systems Manager at NASA's Johnson Space Center in Houston, explains that dining onboard the Station will be far removed from the early days of squeezing out apple sauce from toothpaste tubes.

"We will be sending up a 90 day supply of food which will consist of frozen items, refrigerated items, shelf stable items which can be stored in ambient temperatures, various snack type items, beverages. Hopefully we will be able to incorporate a large amount of fresh fruits and vegetables, if we have the refrigerator capacity, which really enhances the variety of the foods and satisfaction that you get with your food system."



JSC Mockup—Space Station Galley

Literally a home away from home, the Space Station will contain a kitchen equipped with convection and microwave ovens. A comfortable meeting and dining area is being designed, with a window so astronauts can view the Earth whisking by . . .

"...We feel that a lot of the social activities and crew morale will hinge around the food system. That will be a time when people can come together and discuss what's been going on work-wise, relax and if they don't look forward to that period because of the foods that are served, I think it would be detrimental to their morale."

Space foods aboard the U.S. Space Station. Compared to the past, call it cuisine for the cosmos...certainly it gives a new dimension to that old adage of . . . "dining under the stars."

Did You Know?

NASA Has 25 Successful Rocket Launches in A Row

From launch sites in Greenland and Norway and New Mexico and Virginia in the United States, NASA's Wallops Flight Facility, Wallops Island, VA. has a "25 for 25" record for suborbital rocket launches.

This string of 25 successful flights began March 21, 1987 at the Søndre Strømfjord, Greenland launch site with the flight of a Taurus-Tomahawk sounding rocket carrying a plasma physics research payload for Clemson University. NASA Sounding rockets have also been launched from the Andoya Rocket Range in Andenes, Norway and Woomera, Australia.

The principal investigators involved in this space research are from universities and industry as well as NASA. Included are Clemson University, University of Illinois, Cornell University, Utah State University, Penn State University, University of Colorado, University of New Hampshire, Boston University, University of California/Berkley, Stanford University, American Science and Engineering, Inc., and NASA Goddard Space Flight Center.

The Sounding Rocket Program is a very active part of NASA's space science program managed by the Goddard/Wallops Flight Facility in Virginia. This program uses low-cost, sub-orbital vehicles to place scientific instruments in space for brief but often highly productive time intervals. The Sounding Rocket Program currently supports approximately 40-45 launches each year. Approximately 2500 missions have been conducted since 1959 with an 86% mission success rate for that period; and an 89% mission success rate was achieved for over 200 missions in the past five years. The program is, by design, a low cost, quick response activity as compared to Agency orbital missions. The program makes use of surplus military rocket motors and has had a 97% vehicle success rate for the last five years.

NASA "Quality" Slogan Chosen

In October 1987, the NASA SRM&QA's Quality and Productivity Improvement Programs Office initiated a "Quality" slogan contest. This contest was designed to encourage NASA employees to identify a slogan that highlights NASA's commitment to quality and excellence and to stimulate an awareness of the value of a quality-oriented culture.

"Quality—A Commitment to the Future" has been selected as the winning slogan. Submitted by Steven Faldetta—LeRC, this slogan was chosen from over 4,200 submissions by a committee that included representatives from headquarters and all the field centers. The runner up slogans were "NASA: Where Quality Shapes the Future," submitted by Christopher Rumsey—LeRC, and "NASA Excellence Through Quality," submitted by Roger Drake—KSC and Joe Richvalsky—LeRC. The committee felt that these slogans best represent NASA's commitment to excellence and characterize quality as it relates to NASA.

Quality is essential to everything NASA does; the overwhelming response to this contest revealed that NASA employees are indeed quality conscious. The winning slogan and the runners up will be used in a variety of promotional campaigns.

NASA Human Factor: Key Personnel Changes

Culbertson Retires From NASA

Philip E. Culbertson, who served the American space exploration program for 22 years in high level technical and policy positions, retired from NASA in mid-January.

The former Associate Administrator for Policy and Planning, Culbertson has become president of the Lew Evans Foundation, which was established in 1983 in tribute to the former President and Board Chairman of the Grumman Corporation who died in 1972. The purpose of the nonprofit organization is to support and encourage the use of space to improve life on earth.

Culbertson worked at the focal point of the nation's manned space flight programs during this entire NASA career.

Ross Named Deputy at Lewis

Dr. John M. Klineberg, director of the Lewis Research Center, announced the appointment of Lawrence J. Ross to be deputy director of the center.

Ross, 45, served as director of Space Flight Systems at Lewis since 1980.

Recently, Ross undertook several special assignments for NASA Headquarters including directing the investigation into the failure of a Delta launch vehicle; conducting a study of preferred management approaches for the Space Station Project; and conducting a feasibility assessment study of an unmanned flight test of the Shuttle solid rocket booster.

During his 23 years at Lewis, Ross has served in many capacities—including design and test engineer responsible for environmental testing of the Centaur stage and for integration of the Surveyor spacecraft with the Atlas/Centaur vehicle. As Titan/Centaur Manager, he completed development of the Titan/Centaur and directed the launch of the two Viking spacecraft and Helios B.

NASA's Colladay to Direct Defense Advanced Research Agency

On Feb. 1, 1988, Dr. Raymond S. Colladay left NASA to become director of the Defense Advanced Research Projects Agency (DARPA).

Colladay has served as associate administrator for the Office of Aeronautics and Space Technology (OAST), NASA Headquarters, Washington, D.C., since June 1985, following his appointment as OAST deputy associate administrator in April 1982.

As associate administrator, he was responsible for direction of NASA's aeronautics and space research and technology development programs and for the institutional management of NASA's Ames, Langley and Lewis research centers.

Langley Engineer Receives Flight Safety Foundation's De Florez Award

Huey D. Carden, research engineer in the Structures and Dynamics Division at NASA's Langley Research Center, has been awarded the 1987 Admiral Luis de Florez Flight Safety Award. The de Florez award, administered by the Flight Safety Foundation (FSF), recognizes individual contributions to aviation safety made through basic design, device or practice.

Assistant Inspector General

Mr. Danny P. Danigan was appointed NASA's Assistant Inspector General for Management, Office of Inspector General, NASA Headquarters, effective November 1, 1987.

As Assistant Inspector General for Management, Mr. Danigan will provide advice and support to the Inspector General and provide managerial direction for the functional development, implementation and supervision of NASA/OIG management, budget, personnel, and automated data processing activities.

Prior to his appointment with the NASA Office of Inspector General, Mr. Danigan was Assistant Inspector General for Administration at the Department of Interior.

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Pauls Chosen As Associate Director At NASA-Langley

Sidney F. Pauls has been selected as the Associate Director at NASA's Langley Research Center. Pauls will participate with the Director and Deputy Director in the overall management of the center.

A member of the Langley staff since 1963, Pauls served as Assistant Director for Management Operations from June 1986 until November 1987.

Deputy Director for International Relations

Mr. Peter G. Smith was appointed Deputy Director of International Relations in December 1987.

Mr. Smith, who has had a 23-year career in international relations with the Federal Government, has been Chief of the International Program Policy Office of the International Relations Division since 1981.

He began his career as a Foreign Service Officer with the U.S. Department of State in 1964. His foreign assignments ncluded Hong Kong, Seoul and Taipei, as well as two assignments to the Foreign Service Chinese Language and Area Studies program in Taichung, Taiwan. His Washington assignments included service as the Department of State's principal Chinese language interpreter and Officer-in-Charge, People's Republic of China (political) Affairs. He was awarded the Department of State's Superior Honor Award in 1972 for political analyses in support of President Nixon's visit to China.

Mr. Smith joined NASA in 1979 as China Desk Officer in the International Program Policy Office.

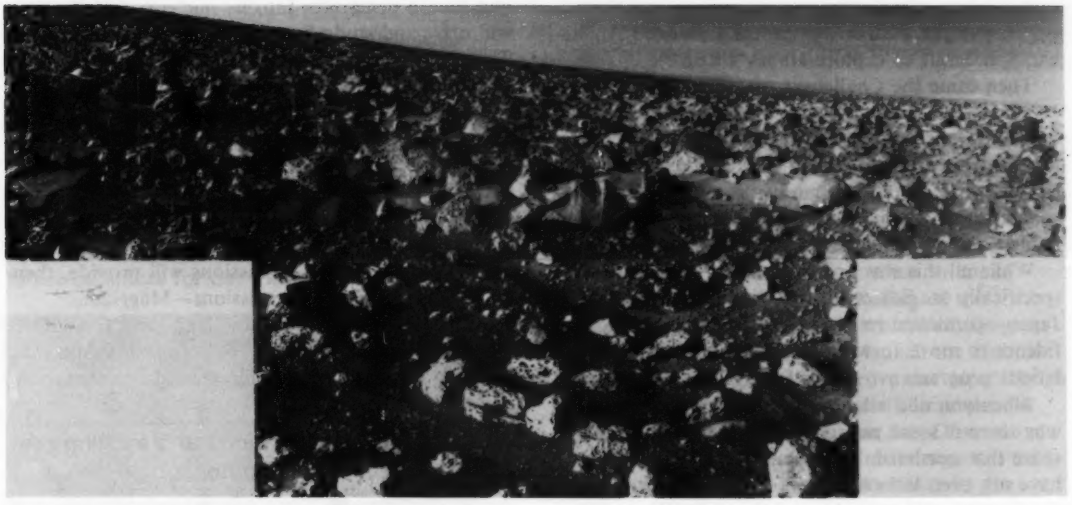
Astronaut Sullivan Honored As One Ten Outstanding Young Persons of the World

Astronaut Dr. Kathryn D. Sullivan was selected as "One of the Outstanding Young Persons of the World" for 1987, by the Jaycees International at its 42nd International World Congress in Amsterdam, the Netherlands, November 12-23.

She and the nine other recipients were introduced at a news conference in Amsterdam on November 16, and received their awards at a ceremony the following day at the RAI Convention Center. More than 2,000 delegates and their guests attended the annual congress.

NASA Engineer Inducted into National Hall of Fame

NASA AMES-DRYDEN FLIGHT RESEARCH FACILITY, Edwards, California . . . Dr. Kenneth W. Iliff, Chief of Fluid and Flight Mechanics Branch at NASA's Ames-Dryden Flight Research Facility was inducted into the National Hall of Fame for Persons with Disabilities in ceremonies held October 17, 1987. Iliff, is known internationally as an expert in aircraft parameter estimation—a field that determines the nature and structure of a system by using the response of that system. He has worked on most of the advanced aircraft flown by NASA in the past 25 years, including the X-15, the XB-70, and the Space Shuttle.



Dr. Leonard Fisk, associate administrator for Space Science spoke at the December 9th symposium on "Solar System Exploration: Origins, Evolution, and Future Prospects" organized by the new Space Policy Institute of George Washington University.

The past 25 years of planetary exploration and discovery have been years of incredible achievement and unparalled excitement. They mark a major milestone in the history of the human species.

Within one generation, we've sent spacecraft to all five planets known to the ancients, and by the end of the decade, we will have visited, at least once, all of the planets in our Solar System, except distant Pluto. Moreover, we've visited Venus, Mars, Jupiter and Saturn several times.

Worlds that once were only tiny dots in the sky to our naked eyes, or blurry images on even the most advanced telescopes, have been revealed to us in all their remarkable complexity. We have seen the ancient canyons and flood plains of Mars; the fiery volcanoes of 10; the incredibly beautiful system of Saturn's Rings; and Miranda, Uranus' Distant Moon, discovered only 40 years ago, but now, thanks to Voyager 2, unveiled as an almost unbelievable patchwork of Terrains.

Everyone has shared in these revelations and in the discovery of dozen of new worlds, large and small. In my view, this is as it should be, for the knowledge we have gleaned should be the heritage of all humankind, and just as space has no national boundaries, so its frontiers are limited only by human creativity and imagination.

But even as we celebrate past achievements, all of us are aware of growing concern—among scientists and nonscientists alike—about the future of planetary exploration.

That concern is rooted in a series of recent events which have converged to form what some believe to be a bleak picture of the future.

Within one generation, we've sent spacecraft to all five planets known to the ancients.

And when you look at what has been happening in recent years, there is some justification for that point of view. Even before the Challenger disaster, the pace of United States' planetary exploration had slowed, with no new planetary missions launched since 1978. Meanwhile, the Soviets continued an active program to explore Venus. They sent four sophisticated spacecraft to Venus, and another two passed Venus and went on to explore Halley's Comet. Furthermore, the Soviets have announced they plan to turn their attention from Venus to Mars next year, with the launching of two Phobos spacecraft. They've also said that they plan a period of extensive exploration of red planet in the 1990's.

In 1986, the United States celebrated the journey of our Interplanetary Cometary Explorer, which made the first flyby of a Comet and paved the way for the International 'Armada' of Spacecraft to Halley's Comet in 1986. But the celebration was

muted because budgetary considerations had forced us, several years earlier, to cancel a planned American Spacecraft to explore Halley's Comet.

Then came the Challenger tragedy, which grounded the primary American launch vehicle. Soon after, safety considerations forced us to cancel the Shuttle's Centaur upper stage and sent us back to the drawing board to modify some planetary spacecraft originally destined for Shuttle-Centaur launches.

While all this was going on, other nations—specifically the Soviet Union, the Europeans and Japan—continued to develop capabilities and confidence to move forward in space with exciting, ambitious programs.

When you add all of this up, I can understand why there is some pessimism about the future. Do I share that pessimism? Absolutely not. Although we have not been launching new missions in recent years, neither have we been sitting idle. We have been building and we have been planning. There are more than a dozen major spacecraft missions currently under construction, and a host of minor projects—all of which will be launched in the years immediately following the resumption of space flight in 1988. Despite the setback that resulted from the Challenger tragedy; despite the delays and the cost-overruns, not one single major space mission has been cancelled. They will all fly and do the forefront science that they were intended to do. And we have real plans for many exciting follow-on missions.

I have jokingly said that today the United States has the world's best space science and applications program on the ground. By the 1990's, with the current and the followon missions, we will have the best space science and applications program in space. We will conduct a balanced and exciting program which is second to none.

Simply stated, it is the intention of the United States Planetary Program to conduct a tour de force of the Solar System in the 1990's. To place an orbiter about most of the accessible bodies in the Solar System—Venus, the Moon, Mars, a Comet, Jupiter, and Saturn.

Magellan will map Venus with radar; Galileo will study the satelites and magnetosphere of Jupiter, and send a probe into its atmosphere; Mars observer will do a detailed survey of the surface chemistry and of the atmosphere of Mars; Lunar Geochemical observer will do an assessment of the resources of the Moon; Comet rendezvous/asteroid flyby, CRAF, will rendezvous and orbit a comet and send a penetrator into its nucleus; and Cassini will orbit and study Saturn, and send a probe into Titan.

Magellan, Galileo, and Mars Observer are, of course, approved missions, being built to be launched in the next few years. Lunar Geochemical Observer is a natural follow-on to Mars observer. CRAF and eventually Cassini are awaiting new starts.

If bits of data returned are somehow a measure of the information these missions will provide, then taken together, these six missions—Magellan, Galileo, Mars Observer, Lgo, Craft, and Cassani—will return essentially twice the amount of data that has been returned from all previous US planetary missions combined.

We will conduct a balanced and exciting program which is second to none.

Our Soviet colleagues have decided to concentrate on Mars during the late 1980's and the 1990's. Our two programs, then, complement each other nicely. We will provide information on a broad range of planetary objects; the Soviets will provide, detailed information on Mars. Indeed, I would argue that it would be scientifically unwise for both of the world's space powers to concentrate all of their resources on Mars. Mars is only one of many objects that we need to study if we are to understand the origin and evolution of the Solar System.

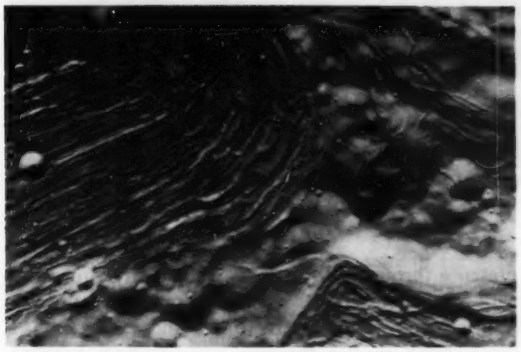
Where our two programs do overlap—on Mars—we should of course coordinate our activities. In fact, as we speak there is a NASA delegation in Moscow discussing cooperation on Mars—for example, the use of our extensive data on Mars from Viking, which is essential for Soviet planning, or use of the deep space network for tracking the Soviet Phobes mission, or coordinating our Mars Observer mission with future Soviet missions. All of these discussions are being conducted as part of the US-Soviet Space Agreement, which was signed last April, and which provides a framework for discussing coordinated activities in essentially all areas of space science.

I would argue that it would be scientifically unwise for both of the world's space powers to concentrate all of their resources on Mars.

All of this planetary Exploration is being undertaken, of course, in the context of a much broader space science and applications program. We should never lose sight of the fact that the most important planet to understand is our own. We have reached

that point in our civilization where we are beginning to inexorably alter our planet on a global scale—and its future habitability is in doubt.

There is perhaps some small comfort in the realization that at the same point in our civilization where we have attained the capability to alter our global environment, we have also attained the capability to measure and to understand these global alterations. Thereby—hopefully—providing ourselves with the means to predict, and to avoid, future calamities for our Planet.



Miranda Chevron

There are two principal technologies—unique to our generation—that are essential for understanding the changes that we are making to our Earth. First, there is the global perspective of our environment that is provided by Space observations. And second, there is the technology of super computers, which allows us to handle the large data sets that satellites return, and to model the implications of these data.

NASA has the lead responsibility in this country to provide measurements from space of our global enviroment and the changes we are inflicting upon it. We will build through the upper atmospheric research satellite—UARS—which will provide measurements of the chemistry and dynamics of the upper atmosphere and definitive measurements of ozone depletion—and through topex, and scatterometer, which will provide global measurements of the dynamics of the Earth's oceans—to the Earth Observing System—EOS—which will provide comprehensive measurements of the Earth, starting in 1995, from the Polar Platform as part of Space Station.

The 1990's will also witness the largest international program ever undertaken in space science—the International Solar-Terrestrial Program, or ISTP. Through both new spacecraft which are to be launched, and current spacecraft which still should be operating in that time frame, data from more than 20 spacecraft—from the US, from Europe,

The 1990's will also witness the largest international program ever undertaken in space science.

from Japan, and from the Soviet Union—will be coordinated to understand the plasma environment of the earth, the radiation and particle outputs from the sun, and their influence on us.

The 1990's should also be an era of unprecedented discovery in astronomy, when we make major advances in our understanding of the universe in which we live—it's the era of the great observatories. In 1989, we will launch the Hubble Space Telescope, to vastly improve our capability to observe the universe in visible and ultraviolet. In 1990, we will launch the Gamma Ray Observatory, to open up the gamma ray sky. It is expected that these will be followed in the mid-1990's by the Advanced X-Ray Astronomical Facility—AXAF, for x-ray astronomy, and in the late 1990's by the Space Infrared Telescope Facility—SIRTF, for infrared astronomy. Through these four great observatories, the universe will be observed over a broad range of the electromagnetic spectrum, from infrared through gamma rays, with unprecedented resolution.

The great observatories are a contribution to science that the United States is uniquely able to provide. The principal here is the same as in ground-based observatories. You make a considerable up-front investment in the optics, and then you keep the facility current by ever improving the instrumentation. Mt. Palamar was built in the 1940's—yet it is still a world-class observatory because the instrumentation is continually upgraded. We are making a considerable investment in the optics of the great observatories, and we will use our unique capability with the shuttle, and eventually the Space Station, to maintain and refurbish the great observatories on orbit, and continually improve their instrumentation. The great observatories will be forefront astronomical facilities for decades to come.

There is, of course, more to space than science. Space is this generation's embodiment of the human need to explore. The moon beckons us to return. Mars entices us to come and explore. And explore we shall. It is not a question of whether we as humans will ever go to Mars, it is only a question of when. Whether it is in this generation of the next, or the one after that, the inexorable march of this civilization into space will eventually make us a multi-planet species.

IO from Voyager 1

When we consider human exploration of Mars, it is important in my judgment—and let me be clear here that I am stating a personal position—that we should never consider going to Mars as a stunt—where simply going to Mars and returning is the total goal, as we did on the Moon. Rather, we should systematically increase our capability to live and to work in space, so that when the time comes for humans to explore Mars, whenever that is, we have the capability to move systematically through ever more ambitious exploration as part of an ever increasing effort to utilize the resources and opportunities of space for the betterment of our species.

The United States Space Program is determined to systematically build the capability that will extend human presence into space. The shuttle, the most capable vehicle ever constructed to take humans to and from space, will fly again safely next summer. The US Space Station will be built, and will provide the United States with permanent human presence in low-earth orbit—from which we can qualify humans to live, work, and perhaps travel in space, and from which, with straightforward modifications, if the time comes, we can construct large-scale vehicles for interplantary missions. And, ELV's will provide US with ready access to space for those science missions which do not require the human presence.

The future belongs to those that are bold enough to dream; yet wise enough to build in the present the capabilities to take advantage of future opportunities. The best strategy for extending human presence throughout the solar system is to proceed, with all due speed, but with deliberate determination, step by step, to learn to live and to work in space. From shuttle, through Space Station, perhaps someday to the Moon, eventually to Mars, the path is clear, it is only a question of the rate of our pace.

We are the pioneering generation leading the way to the ultimate frontier—space. Let us go forward together—with exciting science missions that increase our understanding of the earth, our solar system, and the universe. Let us systematically, and with all due speed, extend human presence into space. Let us go forward in the spirit of international cooperation, on behalf of all humankind. Let us never falter when there are setbacks, but proceed with the sure and certain knowledge that the future of our species lies in space.

Stofan to Retire From NASA on April 1

Associate Administrator for Space Station Andrew J. Stofan will retire from NASA on April 1. Stofan, 53, was appointed June 30, 1986, to the position responsible for developing a permanently manned Space Station by the mid 1990's. Stofan directed the Space Station program through a difficult period marke by significant progress.

While Stofan was the associate administrator, the Space Station office was reorganized to include the establishment of the Space Station program office

in Reston, Va., and eight major contracts were competed and awarded, including those for the design and development of the Space Station, for technical and engineering support to the program office, for the software support environment, for the technical and management information system and for preliminary definition and design of the flight telerobotic servicer.

Stofan also directed the program through a major cost review, which culminated in an Administration-approved plan to develop the Space Station in two phases, and through a major technical and cost review by a committee of the National Research Council, which validated the baseline configuration for the Space Station. Significant progress on technical and programmatic agreements between NASA and the international partners for the development, use and operations phase of the Space Station program also was made during this time.

"The Space Station has made a tremendous amount of progress in the last year and a half, and I give Andy and his team a lot of the credit for getting this program through some very tough times," said NASA Administrator Dr. James C. Fletcher. "Andy has had a brilliant career with NASA and we are sorry to see him retire. NASA and this country owe Andy a debt of gratitude for his years of dedicated work to the nation's civil space program, and we wish him the best."

NASA and the American Society for Engineering Education are planning a conference to celebrate the twenty-fifth anniversity of the NASA/ASEE Summer Faculty Fellowship Program. This very special program will be held in Williamsburg, Virginia, September 14-16, 1988. Former participants, Co-Directors, and ASEE Summer Faculty Committee members will be invited.

For 25 years NASA, through the American Society for Engineering Education Summer Faculty Fellowship Program, has been awarding research fellowships to university science and engineering faculty. This program was designed to stimulate an exchange of ideas between university faculty and NASA scientists and engineers. Selected participants spend approximately 10 weeks working with their professional peers on a research project at a NASA facility. Short courses, workshops, and seminars further enrich the experience.

We are currently in the process of locating current addresses for program alumni. If you were a participant, or know someone who was, please contact:

Sherri McGee
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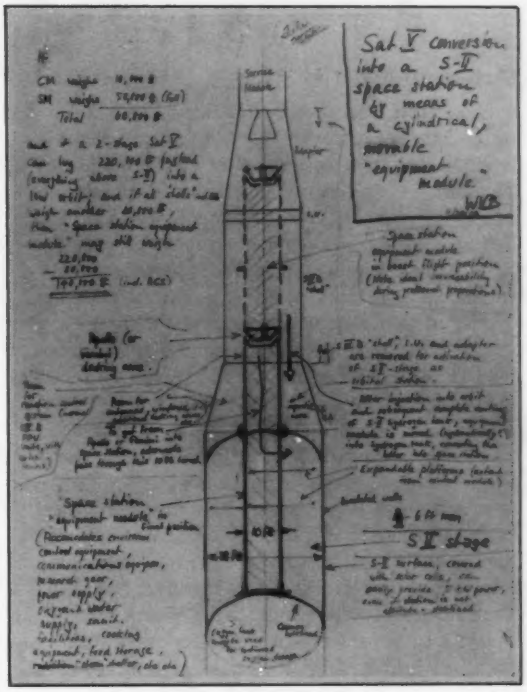


VON BRAUN'S SPACE STATION—This sketch dated Nov. 29, 1964, was found recently in Marshall Center files. It was drawn by Dr. Wernher von Braun and indicates what he envisioned a U.S. Space Station might look like. As noted in the upper right corner, von Braun thought about a Saturn V rocket "conversion into a S-II Space Station by means of a cylindrical, moveable equipment module."

Another Dividend from Air and Space

Research and development in aeronautics and space have provided numerous benefits for all Americans—and at a tiny percentage of the tax dollar. Here is an example:

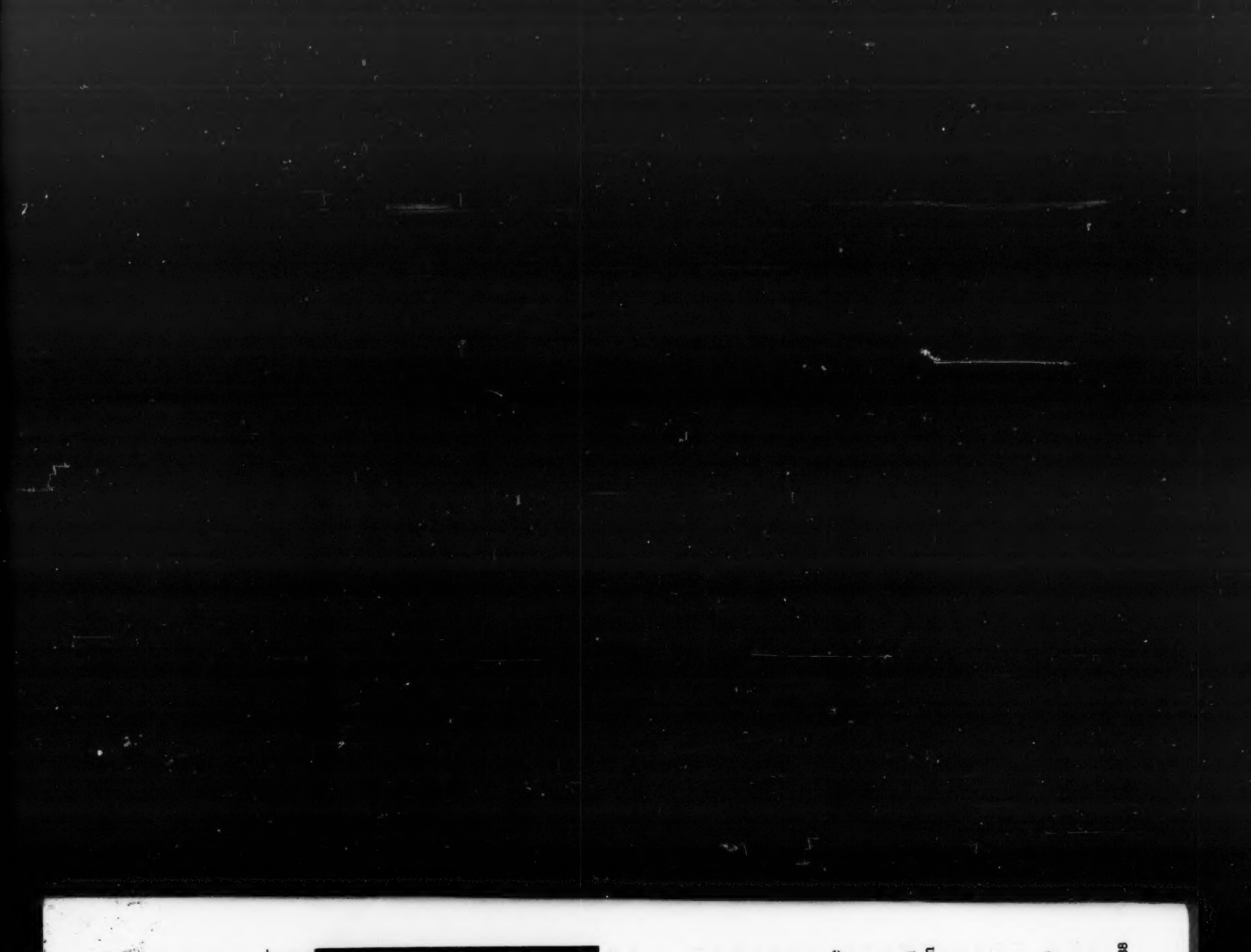
Insulation Material

Spacecraft, manned or unmanned, are subjected to temperature extremes that may range several hundred degrees above or below zero Fahrenheit. Thus, they need superior insulation to protect their onboard equipment and instrumentation. On-orbit thermal control requirements are not the same for all types of equipment, so there is considerable variance among the types of insulation NASA has developed over a quarter century.

An example of a high efficiency superinsulator, used to protect experiments and pressurized modules in the open cargo bay of the Space Shuttle Orbiter, is multilayer insulation, or MLI. Developed in the mid-1970s by Marshall Space Flight Center, the MLI "blanket" employs multiple radiation barriers to retard the flow of energy. This is accomplished by metallizing the surfaces of the barrier material, causing them to reflect radiant energy—retaining wanted heat and blocking unwanted heat or cold. The radiation barriers consist of a plastic film coated on both sides with vapor-deposited layers of metal, such as gold or aluminum. A typical MLI blanket, one that covers the Shuttleborne Spacelab manned laboratory, is composed of 19 layers of "goldized" plastic film separated by layers of dacron netting. The layers of netting reduce loss of energy by convection and serve to hold the blanket together.

Apex Mills Corporation, Lynbrook, New York, a manufacturer of nettings, meshes, scrims and fabrics for industrial use, is a NASA vendor which has been supplying space insulation materials, including netting for MLI, since the late 1960s. The company put this experience to work by adapting the MLI insulation theory to an advanced insulation system—called Texolite® —for consumer and commercial use.

The basic Texolite product is a five-layer insulator, with three layers of netting and two layers of metallized film (aluminized polyethylene). A heavier version for extra insulation is Texolite Plus®, a sandwich containing outer layers of netting covering vacuum-plated film and a core of fiberfill. In the top photo, a sample of the basic Texolite, pulled apart to show the netting, is at upper right; a Texolite Plus sample is at lower left in the photo.

The two products are used in window energy applications as liners for curtains that reduce heat transfer to the insides of buildings and block escape of cool conditioned air, or retain warm air in the heating season. They are also used by makers of cold weather apparel—parkas, jackets, boots—and outdoor gear, such as sleeping bags; their attraction in such applications is that radiant barrier insulation offers excellent warmth retention at minimal weight and bulk.

* NASA does not endorse commercial products developed as a result of its Technology Utilization or Patent Licensing Programs, but it does encourage the widest possible use of its technology.